Union of Concerned Scientists

EXECUTIVE SUMMARY

Turning Soils Into Sponges

How Farmers Can Fight Floods and Droughts

HIGHLIGHTS

As floods and droughts become more frequent and intense, farmers are particularly affected. Current agricultural policies incentivize farming practices that reduce soil's ability to absorb and hold water. A new Union of Concerned Scientists (UCS) analysis finds that a shift to soil-building practices that incorporate ground-covering crops year-round could reduce runoff in flood years by nearly one-fifth and cut flood frequency by the same amount, while also making as much as 16 percent more water available for crop use during droughts. Federal policy changes are needed to support adoption of such systems and reap significant benefits for farmers, downstream communities, and taxpayer-funded disaster relief and crop insurance programs.

Floods and droughts have caused an estimated $340.4 billion in damages in the United States since 1980. On the nation's farms, these extreme weather events devastate crops and livestock, and damage or wash away soil. Taxpayers shoulder a heavy burden for this damage. Between 2011 and 2016, flood- and drought-related claims to the subsidized federal crop insurance program resulted in $38.5 billion in payouts, approximately two-thirds of the total paid by the program. Such claims could double as a result of climate change, costing taxpayers an additional $4 billion to $9 billion annually by 2080.

These disasters also affect cities and towns downstream from farm fields, causing damage to and destruction of homes, businesses, and critical infrastructure. Moreover, floods and droughts can cause the greatest harm in vulnerable communities having the least ability to cope.

While rainfall patterns are outside our control, people can determine how they use land. Over the last several decades, otherwise rational decisions by farmers and policymakers have transformed agricultural landscapes by converting millions of acres of land from mixtures of crops and livestock to systems dominated by one or two plant species. These systems leave soils bare and vulnerable to erosion between summer growing seasons and often rely on plowing practices that degrade soil structure, reduce water infiltration, and increase the flow of water and pollutants across the soil surface.

With rainfall variability increasing, US farmers and policymakers must take steps now to adapt. But there is good news: different farming practices can build rich, porous, spongelike soils that can absorb more water and hold it longer. And research from around the world shows it works.

Edwin Remsberg/USDA-SARE

Practices that keep farmland covered year-round retain more water in soil and can increase resilience to floods and drought.

Building Climate Resilience by Creating Spongelike Soils

We identified more than 150 peer-reviewed field experiments from six continents that evaluated soil and water impacts of five farming methods: **no-till cropping** (in which soil is not plowed); planting of **cover crops** between cash crop seasons (when soil would otherwise be bare); use of **ecological livestock grazing systems** (which intentionally manage animal numbers and rotation through pastures); **integration of crops and livestock**; and use of **perennial crops** (crops such as alfalfa that have living roots in the soil year-round).

To determine how a soil's infiltration rate (the rate at which water enters and moves through the soil) changes with the use of these five farming practices, we performed a rigorous meta-analysis of 126 of these experiments:

- **70 percent of experiments showed an increase in water infiltration** when any of these practices were used.
- **"Continuous living cover" of soil is the best strategy for improving water infiltration**. This cover, which keeps living roots in the soil all year, can be achieved by introducing perennials or cover crops, or by improving grazing practices (in grass-based systems).
- **Perennial crop systems are clear winners at managing heavy rains**. In 28 percent of all studies, the experimental practices increased infiltration enough to absorb a heavy rain event of one inch per hour. This outcome occurred in **more than half** of the experiments involving perennial crops.
- **Cover crops and perennials actually change the structure of the soil**. To hold water longer, soil needs more space between particles (pore space or "porosity"). Analyzing an additional 27 experiments, we found that cover crops and perennial systems **increase porosity by an average of 8 percent** compared with practices that leave the soil bare for significant portions of the year.
- **Continuous cover systems make an average of 9 percent more water available to plants** than do conventional systems.

A Shift in Practices Would Increase Resilience to Floods and Droughts in the Midwest

Next, we analyzed how shifts in farming practices in the Midwest could increase resilience to the kinds of flood and drought events that region has seen in recent years and how this would change under future climate scenarios.

Don Becker/USGS

Soil quality can affect city dwellers as well as farmers. Excess runoff from farms with bare soil can contribute to flooding in towns and cities downstream, with resulting damage to homes, businesses, and critical infrastructure. Cedar Rapids, IA, was inundated by flooding in June 2008.

We used a regional water balance model developed at the US Geological Survey and focused on Iowa, which is representative of midwestern agriculture and weather patterns. Prior analyses have identified parts of Iowa that are less profitable and more susceptible to soil erosion, where improving soil health could have significant economic and environmental benefits. Selecting these less-profitable, more-erodible areas, and assuming (based on our findings above) that a shift to continuous cover practices there would achieve an 8 to 9 percent improvement in key soil properties, we found the following:

- Converting **approximately one-third of Iowa's cropped acres**—today's least-profitable and most-erodible acres—**to perennial crops, or to corn or soybeans grown with a winter cover crop,** would result in significant water savings.
- Such strategic adoption of cover crops and perennials could have lessened the impact of these past floods and droughts:
  - Flooding along the **Missouri River in western Iowa in 2011 caused an estimated $5.3 billion in damages**. Our model predicted **20 percent less runoff** in the Iowa watershed that primarily feeds this river if the most-erodible croplands had been converted to either perennial crops or to corn or soy with a cover crop and 13 percent less runoff if the least-profitable lands had been converted.

- A shift to continuous cover practices also would have reduced flood frequency in watersheds that have experienced significant flood events over the last several decades. Defined as the number of months in which water levels of streams or rivers reach the critical flood inundation stage, **flood frequency could have been reduced by 20 percent in 1993 in eastern Iowa** if the most-erodible croplands had been converted to perennials and cover crops, **by 17 percent in 2008 in Cedar Rapids** if the least-profitable croplands had been converted, and **by 13 percent in 2011 in western Iowa** if the most-erodible acres had been converted.
- Perennials and cover crops **would have provided resilience during the devastating droughts in 1988 and 2012**, each of which caused more than $30 billion in damages. Our model predicted **up to 16 percent more water available to crops** with more perennially based agriculture.

- With these practices, **spongelike soils in Iowa would have retained 400 trillion more gallons of water over the last 35 years**. This is equal to nine years' worth of irrigation water withdrawn across the entire United States at current rates.

USDA

Drought not only deprives crops of the water they need, but the dry soil becomes less able to absorb rain when it does come, which can lead to floods.

How Can Healthy Soils Help Combat the Floods and Droughts of the Future?

While they cannot go back in time, farmers can make land use changes now to reduce the damage from future floods and droughts. We used our model to predict the impact of sponge-like soils in the Iowa of the future, which is projected to be much hotter and slightly wetter by the end of this century. We found that a shift to more continuous cover agriculture would result in the following:

- **7 to 11 percent more water available for crop use**, even with significantly hotter conditions.
- **Runoff reductions ranging from 9 to 15 percent**. The largest runoff reductions came from the wettest future scenario and the conversion of the most-erodible lands to perennial crops or to corn and soybean with a cover crop.

> ***Farmers can improve soil now to reduce damage from future floods and droughts, benefiting both rural areas and cities.***

More crop water use translates into greater crop productivity; farmers could be protected from crop losses, saving taxpayers the burden of higher insurance payouts.

Public Policies Are Needed to Help Farmers

Federal farm policies have played a major role in creating and maintaining current farming systems. The systems we analyzed can build future resilience, but farmers need more research and financial and technical assistance to implement them. Congress and the US Department of Agriculture (USDA) should take the following actions:

- **Expand incentives and strengthen up-front financial support for farmers to adopt soil management practices that deliver flood and drought resilience**. Specific recommended changes include the following:
  - Stronger support for good soil management practices in the **Conservation Stewardship Program**, especially those involving continuous living cover.

  - Increased funding for state and regional solutions through the **Regional Conservation Partnership Program**. This program includes "flood prevention" as a criterion for new conservation projects, but demand has outstripped allocated funding.

- **Provide incentives for risk reduction through soil management in the federal crop insurance program**. To ensure that the crop insurance program promotes resilience to flood and drought losses, Congress and the USDA should do the following:
  - Incorporate **soil quality and management metrics**. High-resolution soil data exists and could be incorporated into crop insurance premium calculations, making premiums more actuarially sound and discouraging the planting of less-productive, less-profitable areas.
  - Improve **enforcement of conservation compliance**. The crop insurance program currently includes minimum requirements for soil and water conservation, but enforcement has been lax.
  - Incorporate **ecological principles** into crop insurance. The crop insurance program has become a barrier to good conservation practices, most notably the adoption of cover crops. Policymakers should give farmers more latitude to implement these systems without jeopardizing their insurance policies.
- **Invest in research to optimize the benefits of good soil management practices**. Taxpayer-supported federal research programs—including the Agriculture and Food Research Initiative, the Sustainable Agriculture Research & Education Program, and the Organic Agriculture Research and Extension Initiative—could do more to optimize the practices addressed in this report. They must be protected, increased, and extended in future appropriations and authorizations.

Edwin Remsberg/USDA-SARE

Soil scientist Natalie Lounsbury and farmer Jack Gurley inspect a tillage radish cover crop as part of a project funded by the Sustainable Agriculture Research & Education Program. This plant's roots penetrate soil deeply, reducing compaction, and increasing water infiltration, making it an excellent cover crop to improve soil structure.

Conclusion

Our analysis indicates that there are tremendous opportunities for more diversified agricultural landscapes that feature more continuous living cover to buffer the negative effects of flood and drought events. Farmers want to be part of the solution to the problems caused by climate change; they can be if they are given support to make beneficial shifts in current crop and soil management.

***Andrea Basche** is a Kendall Science Fellow in the UCS Food and Environment Program.*

Union of Concerned Scientists

FIND THE FULL REPORT AND TECHNICAL APPENDICES ONLINE: www.ucsusa.org/SoilsIntoSponges

The Union of Concerned Scientists puts rigorous, independent science to work to solve our planet's most pressing problems. Joining with people across the country, we combine technical analysis and effective advocacy to create innovative, practical solutions for a healthy, safe, and sustainable future.

NATIONAL HEADQUARTERS
Two Brattle Square
Cambridge, MA 02138-3780
Phone: (617) 547-5552
Fax: (617) 864-9405

WASHINGTON, DC, OFFICE
1825 K St. NW, Suite 800
Washington, DC 20006-1232
Phone: (202) 223-6133
Fax: (202) 223-6162

WEST COAST OFFICE
500 12th St., Suite 340
Oakland, CA 94607-4087
Phone: (510) 843-1872
Fax: (510) 451-3785

MIDWEST OFFICE
One N. LaSalle St., Suite 1904
Chicago, IL 60602-4064
Phone: (312) 578-1750
Fax: (312) 578-1751

WEB: www.ucsusa.org

PRINTED ON RECYCLED PAPER USING VEGETABLE-BASED INKS